COMPIX® 221
Thermal Imaging System

Installation and Operating Instructions

Version 1.3
1/8/2008

NOTICE

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1. INTRODUCTION

The Compix® 221 (hereafter referred to as 221) will work with any Windows XP based computer. The 221A requires a USB 2.0 port. It is designed for non-contact mapping and measuring of surface temperatures. The heart of the system is a sophisticated camera that is sensitive to infrared (IR) radiation. This camera is a reliable, cost-effective tool that provides fast, comprehensive evaluations of thermal performance.

Since elevated temperatures are often cited as a cause of failure in electronic products, thermal phenomena are of particular interest to design and reliability engineers.

An example application of the 221 is the study of temperature distribution and heat flow on electronic circuit boards. In an energized electronic circuit, power is dissipated as heat that produces radiant infrared (IR) energy. The 221 captures this radiation and produces a two-dimensional map, or thermal image, of the object's surface temperatures.

All configurations of the 221 thermal imagers come with Thermal Evaluation Software, typically "**WinTES2**" (hereafter referred to as TES), for camera control, image storage, and display. TES provides the graphical user interface (GUI) as well as the interface that permits the computer to communicate with the Compix IR Camera. TES lets the operator adjust the display, compare images, change colormaps, compensate for different emissivities, read temperatures at specific locations, compute area statistics, and show thermal profiles. An important feature of TES is the use of the industry standard TIFF image file format for storing thermal images. This makes it easy to use the images with other software programs. A second format for image storage is the Compix format (cpx). This format stores the full 32-bit range of temperature data. It is larger than the TIFF file format (192k vs. 95k) and is readable only with Compix software such as TES or Reporter.

The rest of this manual describes the 221 series thermal imagers and their operation in more detail.

NOTE

Before attempting to operate the system you should read sections 2. SYSTEM DESCRIPTION AND OPERATING REQUIREMENTS, 3. INSTALLATION AND SET UP, and 4. MAKING THERMAL IMAGES.

2. SYSTEM DESCRIPTION and OPERATING REQUIREMENTS

The 221 has two principal components: the **camera head** (see figure 1) and the **Thermal Evaluation Software**. The camera head contains the infrared sensor, and circuitry required to capture the infrared video. **Other than the personal computer, no other accessories or supplies are required.**

Figure 1

The 221 systems have been designed to operate in a typical engineering, factory or sheltered field environments.

The camera head should be mounted on a tripod or other stable fixture. The standard fitting is a 1/4 "- 20 threaded female connector, the type normally found on photographic equipment, mounted on the bottom of the camera. The camera head should be located within ten feet (three meters) of the imaging computer. A USB cable (type A/B M/M) is provided for connecting the camera to the computer.

The camera should be treated with the same care given a good visible light camera or other optical instrument. Minor vibration can reduce image quality; major vibration or shock may result in damage. And while the longer wavelength IR energy makes it less sensitive to dirt, care should be taken to keep the optics clean. (See Section 8, Maintenance.)

NOTE

There are no components inside the camera head designed for user service. Removing the cover of the camera may void the warranty. UNDER NO CIRCUMSTANCES SHOULD THE SYSTEM BE OPERATED WITHOUT THE COVERS IN PLACE.

3. INSTALLATION AND SET UP

Unpack the system. Inspect the system for physical damage. If you find shipping damage, stop, inform the carrier and call Compix Customer Service. If possible, store the shipping carton and packing materials for future use.

There are **two distinct steps in the installation procedure**: software installation; camera connection and set-up. You should **perform all of these steps before proceeding** to the verification phase.

NOTE

You may install TES on additional computers to allow others to view images. TES will run without a camera thus letting you load, display and manipulate previously stored images.

Software Installation

TES Installation

The TES software is distributed on a CD-ROM. The software has been designed to work with personal computers running Windows XP. For installation and operation instructions on TES software, refer to the 'install instructions' located in the root directory of the TES distribution media.

USB driver installation

Upon connecting power and the USB to a camera for the first time, the computer will request that drivers be installed. Follow the instructions presented by the computer to complete this process. For current relevant details, refer to 'install instructions' located in the root directory of the TES distribution media.

Hardware Installation

NOTE

Software must be installed before installing hardware unless otherwise stated in the software installation notes. Please check 'install instructions' located in the root directory of the software installation media.

Connecting the Camera

The camera can either sit on a level surface or be mounted to a tripod or stand. Follow instructions in Appendix A for appropriate mounting options below:

- tripod
- table top stand
- heavy duty table top stand

⚠ CAUTION

The DC power input circuitry of the 221 is rated to accommodate up to 6 VDC. A power input voltage in excess of this value may permanently damage the electronics in the camera.

Connect the 5V desktop supply to a suitable source of 110-250VAC 50-60 Hz power and the low voltage output cable coming from the supply to the DC power jack on the rear of the camera. Connect the "B" plug (the narrower of the two ends) of the USB cable to the rear of the 220 camera. Connect the "A" plug of the USB cable to an available "A" receptacle on your PC. If there is a protective cap covering the lens of the camera, make sure to remove it before imaging. Refer to 'USB driver installation' sub-section of 'Software Installation' section for USB driver installation instructions.

4. ACQUIRING THERMAL IMAGES

Once you have completed the set-up steps of section 3, the system is ready for operation.

Definitions: The feet and mounting nut are mounted on the **bottom** of the camera. The side opposite the bottom is the **top**. The lens and focus mechanism are mounted on the **front** or **face** of the camera. The opposite side, with the cable connectors, is the **back**.

Preparing to take images

With its face toward the subject, position the camera head so it is approximately centered over the area to be scanned. The top edge will correspond with the top of the display. The face of the camera head should be parallel to the surface of the subject.

The area scanned by the camera depends on the distance from the camera to the subject. As with a "box" camera, the greater the distance the larger the field of view. Set the camera head at a distance appropriate for the size of the subject.

Start TES by clicking on the WinTES2 icon in Start – Programs – WinTES2 folder.

Refer to the relevant instructions in the Step-by-step folder for important first-time user information. (Double click the "ConfigureWinTES2.htm" icon, or select the WinTES2.htm link near the beginning of the overall Step-by-step document opened by clicking index.htm in the Step-by-step folder.)

Select the "Compix 221" as the camera module from the Options-Plugins menu. WinTES2 will automatically initialize and recognize the camera when you close the selection window.

If the camera power is on when you start WinTES2 or open the Compix 221 camera module, you will see an initialize message concerning the need to reset the camera power. This is normal. If the message "reset power to camera" persists for more than 15 sec., cycle the camera power.

While the system is scanning you may improve the focus by making small adjustments of the focusing knob until edges appear sharp. (See the chapter on OPERATING SUGGESTIONS for suggestions on focusing and framing.)

When you select a display plugin module, which is used to extract temperature data, you will be presented with a window for entering an unlock code. Use the unlock code printed on the installation CD envelope as illustrated in the Step-by-step examples.

Call or E-mail Compix with the Hardware ID code displayed in this dialogue box to obtain a permanent unlock code.

Camera owners may install the software and receive multiple permanent unlock codes for multiple computers at no charge.

Image Touchup

At periodic intervals, the camera will perform an automatic "touchup". It does this to maintain the best image quality in the presence of changing ambient temperatures inside the camera. When these occur, you will hear a faint clicking sound from the camera and there will be a brief momentary interruption in the real-time camera display window during which the image will become a uniform gray.

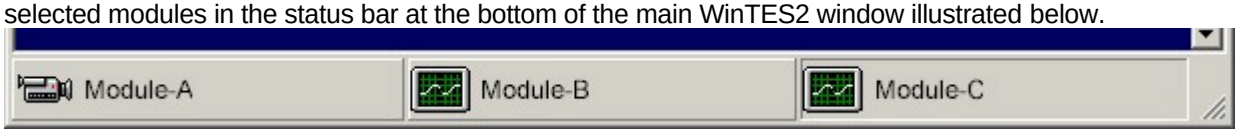
If the scene being imaged changes drastically and the operator feels the image quality may be less than expected, it may be helpful to force a touchup. This can be accomplished by clicking the options button of the camera window and re-selecting the temperature range.

TES Software Overview

Thermal Evaluation Software (TES) gives the user the ability to capture, open, save, and manipulate thermal images. Specifically, WinTES2 consists of a collection of “standard modules” which may be selected and combined according to the user’s needs. Sophisticated users may produce “custom modules” to meet unique needs.

Refer to the help messages in WinTES2 for specific help on each function or module.

The fundamental concept of the modules is that each module may receive input from another module, and may pass information to a successor module. This relation is shown by the left-to-right arrangement of the selected modules in the status bar at the bottom of the main WinTES2 window illustrated below.



In this illustration, Module-A will send its data to Module-B. Whenever Module-B receives data from Module-A, it will do whatever it is configured to do and then pass its data to Module-C. The icons associated with each module are solely to aid in identifying them and neither imply nor serve any functional purpose.

General Rules for Modules and their arrangement.

- A particular module from the list of standard modules may appear zero or more times in the active analysis configuration.
- Data and control is moved from left to right in the order depicted in the status bar.
- Modules may be configured to appear in any order, however some ordering patterns may be of no useful value.
- A module requiring user action will stop the flow of data and will remain the active module until the user response requirement is met. Predecessor modules may continue to generate data and add data sets to the input que of a module waiting for user action.
- There is no mechanism for sending the output of one module to more than a single successor module.
- There is no mechanism for a module to receive data from more than one predecessor module.
- There is no mechanism for sending the output of the last module back to the first module.
- Modules will finish processing their current data before beginning the processing of the next set of data. If the “Discard Data” option is selected, the module will begin processing the most recent (newest) data set and will discard all older data sets. If “Discard Data” option is NOT selected, the module will begin processing the oldest data set, and will keep newer data sets in its input que.
- Receipt of data by a module acts as a trigger to activate the process implemented by that module even if that module doesn’t actually use any of the data it receives.
- Modules do not necessarily alter the data they receive, and many of them pass their input data directly to their successor after performing their own process.

5. OPERATING SUGGESTIONS

Focusing

The 221 cameras utilize a manual focusing mechanism.

Many users find this process easier with the Grayscale colormap, since black and white images tend to appear more natural. A technique, which gives excellent results, involves indirectly shining a 40 to 60 W incandescent light on the unpowered target. To the 221 this is the functional equivalent of an infrared flashbulb. The lamp illuminates the target and the camera displays the reflected IR energy. The resulting image will look much like a visible light picture. Edges will be sharply defined, components will stand out in sharp relief and fine focusing will be easier.

To use this technique, place the lamp about two feet above, and at an angle of about 45° to an unpowered target. Don't shine the light directly into the aperture of the camera. Use Grayscale colormap and take an image. You may have to experiment with the position of the lamp to get the best result. **When finished focusing, turn off the lamp** as high levels of reflected infrared will distort the temperature readings.

Framing or Determining What is Being Viewed

Framing involves two things: first, the aiming of the camera so the target is centered in the image; second, being able to relate specific points in the thermal image to the corresponding locations on the target. The same factors that make it more difficult to focus a thermal image can also make it harder to frame properly. Many users find their first thermal images are ambiguous and confusing. But image interpretation is quickly learned if the user has a working knowledge of the object being scanned. ***Remember****, it is important to have a well-focused image.* **Operating hint**: Look for obvious reference points. Typical hot spots are power resistors, power transistors, and power IC's. Cold or low emissivity components would normally include mounting brackets, metal capacitors or crystal cans and bare copper runs. Surface mount devices, hybrids, etc. are often framed by the contrasting colors of surrounding heat sinks or substrates. Packaged IC's may be identified by the rows of legs or leads on the sides.

Edges of circuit boards are usually easy to find. In an energized board, conduction through the substrate and ground plane normally creates some visible differential heating to the edge of the board. Providing a good background can make the edges easier to see. A dark, matte finish material such as cardboard or black paper behind the board can improve contrast.

Simple markers can be used as pointers. Any small non-conductive (for safety reasons) object at room temperature will work. Plastic tools, non-metallic rulers are also useful. Put the marker on the target as a pointer or an edge indicator, and then take an image. The marker should show up as a distinct dark area against the warmer background of the board and its components. Objects you take out of your pocket will already be warm and may not show up in the image. Some users have reported good success with active (hot) markers. The wire will appear as a distinct hot pattern in the thermal image. The focusing technique described above of using an incandescent lamp or other infrared source is also useful for framing. Make a reflected IR image using that technique. Then, with the lamp off, make a normal thermal image. Watch the display as the thermal image overlays the reflected IR image and you will see which points correspond.Temperature Measurement

The Compix 221 is a sensitive instrument that has the capability to detect small temperature differences. However, non-contact temperature measurements are affected by a number of variables that can change the accuracy of temperature measurements. The following techniques will help improve the accuracy of measurements made with the 221 system.

Be Consistent

Often all that is needed are good relative measurements. The engineer wants to know how one temperature compares with another. Consistency is the key.

- Maintain the same environmental conditions, e.g., ambient temperatures, ventilation and the presence of other heat sources in the room.

- Maintain the same physical set-up for the system. Put the boards in the same orientation -- flat or upright, the same distance from the camera and the same relative position on the display.

-Maintain the same electrical set-up: same power inputs, same program to exercise it. While a circuit board may take several minutes to reach thermal stability, it is not necessary to wait for the board to stabilize, but comparative readings between boards will be more accurate if both circuits are at approximately the same point in their warm-up cycles.

Minimize external sources of infrared energy.

The Compix 221 measures temperature by detecting emitted infrared energy, i.e. the infrared energy generated by the target. Objects also reflect infrared energy from their surroundings.The 221 system (or any other infrared system) can not tell the difference between reflected and emitted energy. Therefore, reflected energy is a potential source of error. Some reflected infrared (IR) energy is unavoidable and the 221 will automatically compensate for typical levels of external IR energy, which are uniformly distributed over the target. Nevertheless, it will be helpful to minimize significant sources of external IR, particularly those that may not be uniformly distributed.

Other sources to avoid are direct sunlight coming through a window and shining on the target, or heat from nearby electronic devices. A general rule of thumb is that if you can feel heat from a source near the target, then it will affect the accuracy of the image.

Minimize the reflectivity of the target.

Another aspect of the problem described above is that some objects naturally reflect more infrared energy than others do. Unfortunately, due to the laws of physics, good reflectors are poor emitters of infrared (emissivity<<1.00). As a result, these objects produce a high ratio of reflected (undesirable) to radiate (desirable) infrared, thus yielding less accurate temperature readings.

The solution is to reduce the reflectivity of these objects. Fortunately, surfaces that are reflective to infrared are usually reflective to visible light. So look for bright, shiny or metallic surfaces, as they will be the problem.

There are several easy ways to reduce reflectivity while minimally effecting the component's thermal performance. A strip of electrical or masking tape on the top surface is one. Anything with a matte surface is a good choice. Or a quick, light buffing with fine emery paper -- just enough to break the surface sheen -- will also help. Most conformal coatings and solder masks provide a low reflectivity surface for thermal images.**Adjust the Emissivity setting**

The default Emissivity setting of the 221 system is 1.00. This is appropriate for the highly emissive (low reflectivity) materials that are most common on circuit boards. For components with lower emissivity, temperature accuracy will be improved if the 221 system's emissivity setting is adjusted to match the component's emissivity. Emissivity tables are available for many of the materials commonly used on printed circuit boards.

Printing and exporting images

TES produces TIFF (Tag Image File Format) images that adhere strictly to the TIFF standard Revision 5.0 for Class-P (Palette Color) Images. Some software applications, which claim to be TIFF compatible use a limited subset of the TIFF specification and may not import Compix TIFF files, so universal compatibility is not assured.

The most reliable way to export a color image is to use the **Copy** command from the menu. This puts the image into the clipboard from where it can be pasted into the appropriate document. Alternatively, **Print**

Screen may be used to copy a full Windows screen to the Clipboard or **Alt Print Screen** will copy only the active window to the clipboard. These objects can usually be pasted into a Word, WordPerfect or other word-processing document.

Additionally, the TIFF thermal image files may be opened in any of a number of applications programs. Finally, images may be captured and saved using any of a number of commercially available screen capture programs.

From these word processing or screen capture programs it is a simple matter to print to a file or printer.

6. MAINTENANCE

Calibration

It is recommended that instrument performance be verified once a year. The instrument should be compared against a calibrated blackbody source. It is recommended the instrument be returned to the factory for repair and recalibration.

Cleaning

Small amounts of dust or lint on the lens surface will have little or no effect on the performance or calibration. It is possible to degrade the lens surface by improper or excessive cleaning techniques. Use the following cleaning techniques carefully and not too frequently.

To remove loose dust or debris, use a gentle stream of dry air. Aerosol-type cans of clean dry air available at camera and electronic stores are suitable for this purpose. For more persistent loose dust or debris you may use a camelhair brush or soft cotton swab ("Q-tip"). **Do not use lens tissues: Lens tissues intended for eye glasses contain chemical additives and lens tissues available in camera stores are often not soft enough.**

Avoid touching the lens surface with your fingers. If you do need to clean off fingerprints or other more resistant material, use clean alcohol or acetone to dampen a soft cotton swab, gently dab, and swipe the spot or fingerprint. If you look at the lens surface under magnification you will probably notice a few tiny defects in the coating that have no measurable effect on the performance of the lens; But if you mistake such a defect for debris and try to remove it you can make the defect larger.

Storage and transporting

The container in which the Compix 221 was originally shipped in should be used for storage or transporting. If this is not possible, make sure adequate protection is provided to avoid damage while in storage or during shipping. This can be accomplished by providing at least a two inch barrier of foam on top, bottom, and all sides of the camera.

Repackaging for shipment

Refer to 'Storage and transporting' section of the Maintenance chapter for instructions on readying the 221 for shipment.

7. USER SUPPORT

User support is available by phone, mail, e-mail or in person at Compix' offices in Lake Oswego, Oregon. Support will normally be available from 8:00 A.M. to 5:30 P.M. Pacific Coast Time, Monday through Friday, excluding national holidays.

User support is generally free of charge on issues relating to interpretation of this manual, the proper operation of the system, routine maintenance and warranty service. Consultation is generally not available on image interpretation problems, fault diagnosis, system modifications or application specific issues, particularly those outside the field of electronic test.

Compix reserves the right to determine, at its sole discretion, the extent of user support made available to any user. A user may be asked to furnish proof of ownership of a Compix 221 system before receiving support.

For support, contact Compix at www.compix.com/email1.htm, by phone at (503) 639-8496 or 1-800-695-6257,
by FAX at **(503) 639-1934**,
or by mail at:

Compix Incorporated
Attn.: User Support/PC2000
P.O. Box 885
Tualatin, OR 97062-0885

When contacting Compix, identify yourself as a user of the Compix 221 system and ask for User Support. It may be helpful for you to have the serial number of your 221 system and the version number of TES you are using at the time of contact.

Visit http://www.compix.com/ for technical articles, price lists, product photos, and other information on current products.If you want to visit us in person, please call us at the number above for directions and to make sure the person best equipped to help you will be available when you arrive.

Our office location/ shipping address is:

Compix Incorporated
15824 SW Upper Boones Ferry Rd
Lake Oswego, OR 97035-4066

8. Compix® 221 LIMITED WARRANTY

Compix warrants to the original buyer that this product shall be free of defects in materials and workmanship and will meet its published specifications for a period of one year following the date of shipment (the Warranty Period). Warranty service will be provided for this product if it is returned to Compix Incorporated, shipment prepaid, during the warranty period. Compix will, at its option, either repair or replace the product at no cost to the buyer, or refund the original purchase price of the product.

Limitations

This warranty shall not apply to defects resulting from accident, misuse, improper maintenance or unauthorized modifications.

The remedies described above -- repair, replacement or refund -- are the buyer's sole and exclusive remedies. Modifications or extensions of this warranty shall be effective only when made in writing, signed by an officer of Compix Incorporated.

THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. COMPIX SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES.

This warranty gives the buyer specific legal rights. The buyer may also have other rights which vary from state to state.

Shipping

During the Warranty Period, Compix will reimburse the buyer for the buyer's reasonable shipping costs for products returned to Compix from locations in the United States and Canada. Compix will also pay the shipping charges to return the product to the buyer.

Before returning a product for service, contact Compix Customer Service for return authorization.

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APPENDIX A. Accessories

Tripod

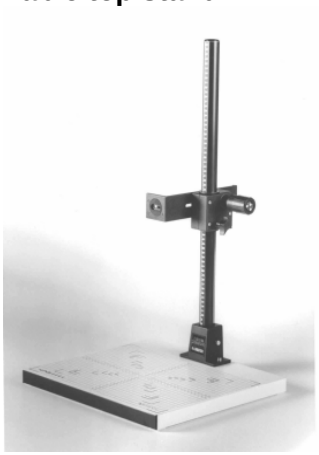
Camera attachment

1. Spread the three legs of the tripod fully.
2. Move the tripod boom to allow for easy access to the ball and socket.
3. Loosen the joint (counter-clockwise) below the tripod neck. Rotate the neck with ball and socket away from the boom to allow for easy access to the ¼ - 20 thread stem. Tighten the joint below the tripod neck.
4. Connect the camera head to the ball and socket via the ¼ - 20 nut and threaded stem.

Operation

Use the thumbscrews at the ball and socket, neck, boom mount, leg holder to position the camera head as needed. The body of the tripod can also be extended if needed.

Table top stand



Assembly

1. Attach the post to base using two bolts provided.
2. Attach the clamp assembly to the post.

Camera attachment

1. Attach the camera via the ¼ - 20 nut to the ¼ - 20 thumbscrew of the table top stand.

Operation

While holding the camera head with one hand, loosen the clamp assembly lock with the other, then rotate the clamp assembly positioning handle to move the camera up or down. Tighten the clamp assembly lock when camera is at desired location.

Medical tripod

Assembly

If tripod is not already assembled, attach head assembly to the base of the tripod.

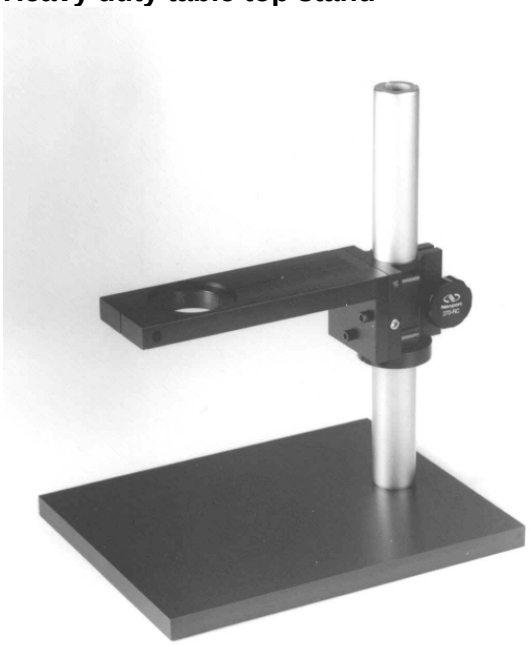
Camera attachment

Attach the camera via the ¼ - 20 nut to the ¼ - 20 thumbscrew of the table top stand.

Operation

Thumbscrews at pivot points can be loosened, then tightened, to position the camera head as needed.

Heavy duty table top stand



Assembly

1. Attach the post to the base plate using the long-shaft socket driver.

2. Install the safety clamp

3. Install the camera support arm and pinion assembly onto the vertical shaft. Make sure the arm support is oriented to the top of the pinion assembly. Gradually lower the assembly until the pinion engages the rack. Do not force.

The optional positioner, if ordered, is shipped separately to prevent damage to the micrometer adjustment mechanisms. To install it, follow steps 4-8.4. Remove the four #6-32 socket-head cap screws from their holes in the base plate.

5. Position the X-Y positioner over these four holes. The positioner may be mounted in any of four orientations. The most common is to have one adjustment in front and the other to the right. However, on a crowded bench, better protection against damage and accidental change may be worth the inconvenience of mounting one adjustment to the back and the other to either side as dictated by the environment or by the preference of the operator.

6. Install all four cap screws finger tight. It may be necessary to move the stage of the positioner to get satisfactory access. Avoid manually moving the stage against the force of the return springs, and, especially, DO NOT LET THE STAGE RETURN OUT OF CONTROL TO ITS REST POSITION. (Repeatedly letting the stage slam against its stops under force of the return springs could damage the micrometer mechanisms.)

Finally, tighten all four screws uniformly. Do not over tighten. Tighten them just enough to keep them from vibrating loose or allowing the positioner to wiggle when operating the micrometers. Use a torque screwdriver, if possible, and tighten the screws to 40 in-oz.

Camera attachment

1. Position the safety ring four inches (100mm) or more above the base. Tighten it securely in this position. Later you will adjust the height of this ring so that the lens cannot possibly touch or crash into the object being imaged.

2. Adjust the camera height by rotating the knurled knobs of the support arm and pinion assembly.3. Re-position the safety ring so that the camera cannot come down too close to the object being imaged. Tighten the safety ring. Always keep the safety ring positioned and tightened to insure that the lens cannot fall onto, or come in contact with the object being imaged.

Operation

Set up the object to be imaged on a stable surface. (If the grid of #6-32 threaded holes of the optional X-Y positioner are used, be careful that the screws never engage beyond 0.2 inches (0.5mm) and protrude through the stage. Nylon screws are recommended. Alternatively, a sample can often be installed satisfactorily using masking tape or equivalent.)

Adjust the safety ring so that, with the lens cover in place, the camera cannot come down any further than to have the lens cover almost touching the sample.

To raise or lower the camera, adjust the tension as needed, tight and slowly rotate the height adjustment knob. The tension will automatically increase as you lower the camera, or decrease as you raise it. To maintain constant tension, turn both knobs together.

Connect the camera cable, apply power, and proceed to operate in the normal manner (see chapter 3).

⚠ **CAUTION: Never touch the lens or allow any object to touch or strike the lens.**

Maintenance

Occasionally inspect all parts of the heavy duty stand, and X-Y positioner for damage and for accumulation of dust and debris. Clean and lubricate (using a light oil) all moving parts as needed.

If it is necessary to ship the heavy duty stand, it is recommended that the X-Y positioner be removed and packed separately. Make sure the support arm and safety clamp are tight, and use plenty of packing material.

APPENDIX B. Efficiency, Emissivity, Lens Factor, and Noise

Both **emissivity** and **lens factor** work alike to express the efficiency with which radiation from that object reaches the sensor of the camera. Use what you already know about emissivity effects to understand the effect of the Lens Factor.

The overall value for efficiency may be determined by multiplying the emissivity and lens factor. In the following examples, the first three lines represent mathematically equivalent situations:

Emissivity	Lens Factor	Efficiency
.49	1.00	.49
1.00	.49	.49
.70	.70	.49
1.00	1.00	1.00

Background noise is exaggerated by non-unity lens factor or emissivity settings. To fully understand this it may be helpful to view the top two lines of the **Apparent Temperature table** below. The first entry of the second row simply indicates that for a 100% emissivity object, 30°C would be reported; the second entry indicates that a real surface of 0.9 (90%) emissivity would appear the same as a blackbody of only 29.1° C.

Another way of looking at the information contained in this table is to realize that if the emissivity were set to 90%, then a black body of only 29.1° C would be converted to read out as 30° C. Similarly, the third entry from the end in the first row indicates that a blackbody of only 22.9° C would be converted to read 30° C if the emissivity setting were 20%.

Apparent Temperature of a 30°C Surface for various Emissivity %.

Emissivity	Apparent Surface Temperature
100	30
90	29.1
80	28.3
70	27.4
60	26.5
50	25.6
40	24.7
30	23.8
20	22.9
10	21.9
0	21.0

The background noise reported with a 100% efficiency setting (100 emissivity and 100 lens factor) will typically span two to three degrees. Suppose a particular instrument reports background noise of 21° C to 22.9° C. Suppose these values were converted with a lens factor of 20%. By definition, 21° C is converted to the same value, 21° C. But 22.9° C, as shown in the table fragment above, would be reported as 30.0° C, resulting in a 9-degree span for the temperature-equivalent background noise.

Emissivities of common electronic materials

Material	Emissivity (approximate)
Aluminum, polished	.1-.25
Aluminum, anodized	.50-.60
Gold, polished	.01-.04
Glass, smooth	.85-.95
Water (liquid state)	.95-.97
Black body	1
Plastic IC package	.88-.95
Ceramic IC Package	.80-.85
Silicon wafer	IR Transparent
Simpson emissivity dots	.95
Black electrical tape	.93-.95
Masking tape	.82-.85
Flat black paint	.93-.95